RECOGNITION TIME AS A MEASURE OF CONFIDENCE

An Experimental Study of Redintegration

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BY
GEORGENE HOFFMAN SEWARD

Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, in the Faculty of Philosophy, Columbia University

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I. HISTORICAL INTRODUCTION

In the days when arm-chair speculation flourished, there were many attempts to analyze confidence or the "belief consciousness." For the Associationists belief was association of ideas. Others introduced the factor of harmony with previous experience as an essential characteristic. The emotional aspect of confidence found favor with the structuralists, while its relation to activity was extolled by the "motor psychologists." According to another concept belief was an ultimate, unanalyzable datum of experience. With the notable exceptions of the introspective studies of Okabe (31) and Roback (36), and the recent work of Lund (24), there have been few experimental checks on theory, so that at the present time the nature of the "belief consciousness" is still a moot question, and interest has shifted to the more quantitative aspects of confidence that yield to the laboratory technic of objective measurement.

Since variations in degree of confidence have been observed under certain conditions, a study of these conditions affords a suggestive approach to the study of confidence. Hollingworth draws our attention to the fact that "there is no reason to suppose that confidence displays sharply marked stages or degrees. Instead . . . it is a continuous function of the difficulty of the situation, the completeness of the data, the accuracy of the reaction, and, perhaps, of the mode of report."[1] The "difficulty of the situation" is largely determined by the amount of data at the subject's disposal, and is expressed by the speed and accuracy of his performance. By varying "completeness of data," then, changes in speed and accuracy are produced which may serve as indices of accompanying differences in degree of confidence.

In laboratory experiments on the differential threshold where the task presents gradations of difficulty, the resultant variations in accuracy and speed have been found by many investigators to correspond closely with different degrees of confidence. As early as 1892, Fullerton and Cattell (5) in their work on the perception of small differences showed that confidence varied nearly as the percentage of right cases.

[1] (16) p. 298.

Griffing (7) in his investigation of sensations from pressure and impact also found estimations of confidence to correspond with objective accuracy. Whipple (46) discovered the relation between speed of judgment and its certainty and correctness in the discrimination of clangs and tones. Later, Henmon (10) correlated speed and accuracy in the judgment of lines, and found a uniform increase in time to be accompanied by decrease in both confidence and accuracy. A recent experimental investigation by Garrett (6) on the relation of accuracy to speed in the judgments of psychophysical magnitudes, showed that the percentage of sure and fairly sure judgments closely parallelled the accuracy records. Williamson (47) previously found that confidence could be quantitatively measured in terms of difference discriminations not only in psychophysical magnitudes but even in such material as common beliefs. His results also indicated that "confidence-strength is merely graduated to increased objective difference." In a later study Trow (45), correlating confidence ratings with scores in a wide range of tests, included beliefs, ethical judgments, judgments of poetry, logical fallacies, handwriting comparisons, as well as the more objective performances of sensory discrimination, memory span, incidental memory and recognition. His results were in accord with those previously cited; judgments given with a high degree of confidence were more apt to be right than the others, but the individuals who were the most confident were no more apt to be right than the others. A less extensive study of the same type by the present author (12) in which sensory discrimination, Münsterberg "A" test for judgment, recall and recognition were studied in connection with confidence ratings, confirmed these findings.

These investigators in the field of difference discrimination seem to agree on the relation of confidence to accuracy within the range of a single individual's judgments, but they find such marked individual differences in the meanings attached to the degrees of confidence that this principle does not hold among different subjects. "This difference," according to Woodworth, "is in part temperamental, and in part merely a chance variation such as would be expected in the process of dividing a continuum into a series of compartments without objective aid or control."[2]

[2] (49) p. 65.

With regard to the relation between confidence and accuracy, Hollingworth (14) found in his study of the judgment of personal efficiency that "judgments of performance resemble judgments of sensory discrimination and recognition memory." An individual's judgment of the efficiency or inefficiency of his own performance possessed a degree of correctness which varied with his degree of confidence. These results received corroboration in a further study (15) comparing the judgments of performer and witness. Similar results were obtained by Bridges (1) in his work on decision types, in which the subjects were required to decide between various pairs of alternatives and to express their confidence in their judgments. He found that in subjective decisions the confident judgment of any individual was more apt to be constant than one which lacked confidence, and in objective decisions, the confident judgment was more apt to be accurate, but the differences were slight.

Other fields of psychological research have contributed more evidence on this point. In a study by Rousmanière (37) on certainty and attention, every subject showed more certainty in judgments made about the aspect of the field toward which his attention was directed, and the percentage of error was lowest for the highest degree of certainty. Mikulski (28), investigating the difference in perception and attention between normal and abnormal subjects, discovered incidentally that confident perceptions were characteristically more correct.

The relation between speed and confidence was brought out by means of a unique technic in the work of Metcalf (26) in 1917 on the analysis of the "conscious attitudes of certainty and uncertainty" on the motor side. The task he set his subjects was that of drawing figures with the hand out of sight. The apparatus gave records of the accuracy of these movements and of all changes in rate and pressure which occurred. He found that the accuracy of the drawing seemed less important than the other characteristics for the appearance of certainty. Certainty was correlated with a definite type of pressure curve, and uncertainty with a variation from this type. Certainty was also correlated with a faster and especially with an accelerating rate of drawing.

The tendency to bluff is an aspect of confident behavior which has been investigated by Riddle (34). A poker game was used as a social situation in which the individual player's

reactions were examined. She found that the great "risker" as a rule had the poorest hands and the least money in his pile. He was also apt to win less frequently than the others.

No field of psychological investigation affords conditions better suited to the study of confidence in its relation to completeness of data, accuracy and speed than that of recognition memory. Many conflicting theories have arisen as explanations of the recognitive process. As M. H. and E. K. Strong point out, much of the controversy in the past has been between those who maintain that it is due to ease and those who maintain that it is due to fusion between the new percept and the old, or to the arousal of associations previously present.[3] As a result of careful research on the subject, they are convinced that both these factors enter into the process of recognition, but that recognition itself is due to an increased facility of nerve functioning. The Strongs formulate their theory as follows: "Recognition is then due first of all to the fact that when an object is seen again it arouses the same associations that it did when it was first seen. The nervous current traverses the same pathways again that it did before. This condition is essential for recognition, but it is not the explanation of the recognition itself. The recognition arises as a conscious awareness that the second discharge has flowed more easily than it would if it had been a discharge to a new object and it has flowed with more difficulty than if it had been a discharge to an old familiar object. This ease may be measured objectively in reaction-time. It is estimated subjectively in terms of consciouness of strangeness or familiarity."[4] Similar observations led Müller (29) to practically the same conclusion. He found in his work with nonsense syllables that if a syllable recalled in the test brought with it a word which it suggested in the process of learning, this added confidence to the subject's belief in its correctness. Woodworth has characterized such accounts as the "reaction theory of recognition," which he himself accepts. "When a fact arouses the same association or reaction as it did on a previous occasion, it is recognized. It is the reaction that gives the feeling of familiarity."[5]

In a later work, Woodworth elaborates this hypothesis. "The response we made to the object in its original setting was a response to the whole situation, object plus setting; our re-

[3] (42) p. 360.
[4] Ibid.
[5] (51) p. 115.

sponse to the object was colored by its setting. When we now recognize the object, we make the same response to the object in a different setting; the response originally called out by the object *plus* its setting is now aroused by the object alone."[6]

The capacity of a part to arouse a response previously made to a more complex whole is the basis of the redintegrative theory of recognition. Hollingworth, the chief exponent and elaborator of this hypothesis, postulates that the laws of recognition are the general redintegrative principles. According to this theory, "a mental process or redintegrative sequence" is "a series of changes in which a partial antecedent functions appropriately or adequately for a former antecedent of greater complexity." ". . . The original antecedent (or its very like) is not required to produce a given consequent (or its like). Instead, some detail or fragment is adequate to touch off a consequent of the type formerly evoked by a more complex antecedent. Of this antecedent the instigating fragment (or its like) was formerly but a part."[7] As applied to recognition, "recognition is more certain (complete) when the cue approximates a complete recurrence of the original, and its certainty varies with the completeness of signature. If I hear the footsteps and also see the gray uniform, my recognition of the postman is both more prompt, more sure, and more often confirmed."[8] Thus speed and accuracy are the objective, and confidence the subjective accompaniments of completeness of data.

The literature on recognition memory and closely allied fields is rich in experimental data bearing on these points and is suggestive of further research. German investigators have contributed generously to our knowledge along this line. In 1901 Finzi (3) studied "Auffassungsfähigkeit" and "Merkfähigkeit" by means of letters, numbers and nonsense syllables. He introduced various changes between the presentation and the test series, and required his subjects to designate which stimuli they felt certain had previously appeared and which seemed doubtful. He found that as the feeling of uncertainty increased the actual unreliability of memory did not increase to the same extent. Peters' (33) study of association by similarity in 1910 involved recognitive memory and had results that bear directly on the present research. A

[6] (50) p. 358.
[7] (17) p. 5.
[8] (17) p. 117.

series of nonsense syllables were first displayed in the Ranschburg mnemometer, followed later by a second presentation by the paired associates method of modified similar syllables in which one of the sounds had been "changed." The subjects were instructed that the syllables were to be changed and their task was to name the learned similar syllable as quickly as possible. The reaction time was recorded by a fifth-second stop watch. The reproductions were characterized by the subjects as either surely correct, doubtful or false. He found that the judgments "surely correct" were quicker and occurred more frequently in connection with cases which actually were right than among the wrong, while the "doubtful" and "false" judgments were more often wrong than right, and had an increased reaction time. But the reaction time of the wrong cases believed to be "surely correct" was less than that of the "doubtful" cases which were actually accurate. Peters concluded, therefore, that the size of the reaction time is influenced primarily by the subject's certainty, and secondarily by the objective accuracy. This finding received corroboration in Frankfurther's and Thiele's (4) study of the relation between imagery type and sensory mode of learning. These investigators presented a series of nonsense words of two syllables through different sense modes. Then the leading syllable was presented in a similar way and the subject required to supply the rest of the word. They found that the most certain reactions occurred in connection with the learning method corresponding to the sensory type of the subject, and moreover that "Schnelligkeit der Reaktion und Sicherheitsgefühle parallel gehen." About the same time, Jesinghaus (19), using various memory methods with four-place digits, also asserted this relationship between reaction time and the feeling of certainty.

Müller (29), in his important work on memory which was published about this time, postulated speed of reproduction as a "Richtigkeitskriterium." He found in working with nonsense syllables that in many cases of less certainty the reaction time was especially lengthened. With regard to confidence ratings, he warned us of their subjective and shifting character, which makes direct intercomparisons among different individuals meaningless. A much later study by Ries (35) is also concerned with the Richtigkeitsbewusstsein. He used drawings, odors, digits, letters and words as stimuli for differ-

ent groups of subjects. He found in addition to the criteria of correctness postulated by Müller a further criterion in the fullness of the image. The image of a letter will be held as correct more easily if it arises in connection with the whole series in its right place than when it arises in isolation. Helps in the form of meaning and connection play a great role in producing the Richtigkeitsbewusstsein. Furthermore the Richtigkeitsbewusstsein is narrower if the identification was not sure. One can easily be deceived about something perceived if it is only uncertainly identified. In accord with Müller, he found wide individual differences in what constitutes evidence sufficient to warrant making a report with Bestimmtheit. Heine (9), working with Müller on recognition, used nonsense syllables presented by means of a kymograph. The subjects responded verbally with "a" if they had a definite impression of familiarity; if this were lacking they were to say "ei," and if uncertain they were to say "u." These responses were made by a lip-key attached to a device for recording the time of recognition. The investigator found that the positive recognitions were quicker than the negative, and these than the undecided cases. In the same year Meyer (27) performed an experiment on preparation and recognition employing essentially the same technic but introducing different kinds of nonsense syllables. Some of the stimuli in the presentation series were accented while others were not. In the test series certain syllables corresponded to those that had been accented in the first series, but were now unaccented. It was believed that such stimuli were in a state of greater readiness because of the facilitation caused by their previous appearance. He found that simple recognition of a syllable was favored if it had been previously set in readiness by another syllable or number of syllables. Moreover, the "judgment-times" of "very certain" recognitions were shorter than those designated merely as "certain," but these were shorter than those that were "uncertain."

During this period of productive research in the field of memory in Germany, a corresponding activity was taking place in the United States. In 1913 Hollingworth (13) investigated the difference between recall and recognition, using for his recognition material nonsense syllables, geometric forms and advertisements, and requiring his subjects to distinguish four degrees of confidence. He found that the cor-

rectness of "slightly certain" and "mere guess" recognitions was about the same for all four kinds of material, but that the higher degrees of confidence possessed more and more validity as one passed from nonsense syllables to more meaningful material. He gives these results a redintegrative interpretation in his most recent work: "Complexity involves a greater array of possibly effective instigative clues, and meaningfulness implies ready consequents based on previous contexts. Recognition (perception) is thus favored by the number of available cues (completeness of data) and by their familiarity. . . . The confidence ratings express the subjective (introspective) aspect, and the percentages of correctness express the objective feature of the redintegrative effectiveness of the cues provided."[9]

Just prior to this work, Strong (38) studied the effect of length of series on recognition memory. He used six series of advertisements varying in length from 5 to 150 each. The test series, which contained the original stimuli and an equal number of others, followed immediately and were to be sorted by the subjects into four piles corresponding with different degrees of certainty. He found that the accuracy of recognitions decreased rather slowly with "absolutely certain" recognitions and rather rapidly with "reasonably sure" recognitions as the length of the series increased, while it approximated zero with very doubtful recognitions regardless of the length of the series. Moreover, recognitions not accompanied by a feeling of absolute certainty were practically no better than random guesses. The doubtful recognitions were virtually worthless at all times. The following year the same investigator (39) studied the effect of time interval on recognition memory, using a fixed length of series of twenty words but employing thirteen different time intervals between the presentation and the test. The subjects were required to express their confidence according to four degrees. As the interval between exposure and recognition was increased, the certainty with which the recognition was made steadily decreased, and, as in his earlier study, it appeared that recognitions not accompanied with a feeling of absolute certainty were little better than random guesses. Here for the first time he formulated his theory of recognition as due to the fact that the same mental process has accompanied the word the

[9] (17) p. 129.

second time that did the first time. A very recent study of the effect of time interval on recognition has been made by Wylie (53). She presented Chinese symbols in an Ach memory exposure apparatus set in circuit with a Hipp chronoscope for recording reaction time. Estimates of confidence were given in percentages. More correct recognitions were reported in connection with the shorter periods. The subjects were slightly surer when they recognized the new as new than the old as old, but the shortest reaction times were for the old as old.

In 1915 Strong (40) reported an "interesting sex difference which throws light on the part-whole type of reaction with which we are concerned." Twenty-five full-page advertisements were shown the subject in succession. He was then supplied with a pile of sheets of paper on each of which appeared a *piece* of an "ad." There were 291 such pieces. About half were portions of the original twenty-five stimuli, while the other half were portions of twenty-five new advertisements. The test consisted in seeing to what extent the subject could correctly pick out the various details that had occurred in the presentation series. The subject expressed his confidence by assigning each sheet to one of four piles representing different degrees of confidence. Strong found that the women could correctly identify fifty per cent more details than the men under the same conditions.

In the same year Woods (48) reported an experiment by Katzaroff (20) which is interesting on the technical side, because it employed a method that might prove useful in studying redintegrative behavior. A series of designs were presented in a tachistoscope, followed by a second presentation which included in addition to the original stimuli other very similar drawings and also some that were totally new. The subject, who, however, had been previously informed that these confusion drawings were to be introduced, was given the task of determining whether a given test stimulus was identical, similar or wholly different from one seen in the first series. Four degrees of certainty were to be distinguished. Contrary to the results of other investigators, the author failed to find a correlation between subjective certainty and objective correctness.

Feingold's (2) investigation of recognition and discrimination, which was published in 1915, followed the same general

technic but was more comprehensive and suggestive. In one part pairs of words were used which varied in degree of similarity. Some had the first two letters in common, others the first three, others still the first four, up to those that had all but the last letter in common. He found that as the similarity increased the discriminative ability decreased. In another part of his work he used picture postcards. The critical card was exposed among a fixed number of other cards, and after twenty seconds the same setting was reëxposed with the variable card in place of the original or with no change at all as the case may have been. He found that the objects had to reach at least twenty-five per cent similarity before they could have a confusing effect on the process of recognition.

Paynter's (32) work on trade-mark infringement was a still more analytic study of the effect of similarity on recognitive ability. The presentation series contained twenty trade-marks, ten of which were "original" litigated trade-marks and ten chosen at random from magazine advertisements. In the test series there occurred ten imitations of the "originals," ten duplicates of the remaining ten in the presentation series and twenty new trade-marks. He found that the lower the degree of deceptive similarity between two trade-marks, the greater was the ability to recognize the change. Moreover the scores of confusion of the imitations did not divide into two distinct groups, those likely to deceive and those not likely to deceive, but their distribution formed a continuum.

The recognition experiment has been very recently used to confirm the redintegrative theory of confidence by Lund (23). In the presentation series A, ten nonsense words were presented in a fall tachistoscope at ten-second intervals. Later they were mingled with the words of series B which were duplicates of A except that one letter had been changed in every word, and series C in which two letters had been changed. Confidence in the recognitions was expressed on a scale of four degrees. He found that owing to the greater similarity false responses occurred more frequently in connection with words of series B than C. This was paralleled by B's taking a position intermediate between A and C in the average ratings of confidence. These data show that "the degree of similarity which a present situation has with a previous situation, and therefore the degree of similarity which present perceptual

and associative reactions have with previous ones, determines the degree of confidence. Confidence increases according to the number and intensity of the particular items or stimuli which initiate a familiar reaction, and the feeling results from the passage of a nerve current along a previously used brain path or across a closely bound synapse."[10] In terms of redintegration, "the degree of confidence is determined by the ease of redintegration; i.e., by the ease with which a present situation leads over into a familiar pattern response."[11]

[10] (23) p. 376.
[11] (23) p. 373.

II. PLAN OF THE PRESENT RESEARCH

1. *Problem*

A survey of the literature suggests that the conditions afforded by the recognition experiment are adapted to the study of confidence. By varying the degree of similarity between the material of the presentation and test series, we are able to establish situations varying in the ease or difficulty with which the recognitive response is elicited. This ease-difficulty factor is subjectively reported as degree of confidence and objectively expressed by the speed of response. The aim of the present research is to determine the extent to which recognition time may serve as a measure of confidence.

We have already noted[12] that the recognitive process illustrates the general laws of redintegration. In the test situation certain stimuli are presented that previously occurred in the original situation. It is unnecessary, however, for the total previous situation to be reproduced in order that the recognitive response may be elicited. Some detail is adequate to evoke a consequent previously evoked by the complex antecedent of which it was formerly but a part. Thus the auditory stimulus of a friend's voice over the telephone is potent to instigate a "warm glow" of the same type that previously occurred in response to a more complex antecedent including such factors as his handshake, smile, mannerisms, etc. The detail of the transmitted voice has served as a surrogate for the antecedent of greater complexity of which it was formerly a part, and has evoked a consequent of the same type.

The present research affords controlled conditions for the study of the redintegrative sequence in recognition. Since the test stimuli bear varying degrees of resemblance to the presentation stimuli, they reproduce the presentation stimuli with varying degrees of completeness. As the degree of similarity increases, the original situation is represented by a greater and greater number of details which may function as cues in the instigation of the redintegrative response. This greater facility in the evocation of the redintegrative response is manifested subjectively by greater confidence; "recognition is more certain (complete) when the cue approximates a complete re-

[12] p. 8.

currence of the original, and its certainty varies with the completeness of signature."[13] It is manifested objectively in increased speed of reaction: "reaction times thus measure . . . the ease with which a specified cue evokes its predetermined response or consequent."[14]

2. *Material*

a. DESCRIPTION. In order to create situations which varied in completeness of the data presented, material was chosen showing different degrees of resemblance betwen the stimuli of the presentation and the test series. Thirty stimulus cards made from fancy papers of varied design and color constituted the presentation series. Thirty sets of test cards were made consisting of three stimuli each, A, B, and C. Those of the A series were identical with the stimuli of the presentation series and in fact were used as such; those of the B series were similar to their corresponding "originals" in the A series in general type of design and color, but changes had been introduced in the configuration of the elements of the design; in the C group a further departure from the first series was made in the alteration of the color in addition to further change in configuration, but these stimuli still bore a family resemblance to those of the original series. In addition to these three series of "related" stimuli, group X, which comprised ten "new" stimuli, was introduced into the test series to prevent the subject from adopting a mental set for similar stimuli. Some of these "new" stimuli might result in occasional confusion with those of the "related" groups, due to a slight similarity in texture, color or design, while others were altogether different and were intended to represent the zero point of resemblance; e.g., a picture of fruit, and a pen and ink sketch of a man's face. For convenience in handling, the papers were mounted on bristol board, 74 by 51 mm.

b. METHOD OF ROTATING MATERIAL FOR DIFFERENT GROUPS OF SUBJECTS. In order to present all the test stimuli in their various relations to the first series, three presentations would be required. Since results obtained on the same subjects by this procedure would have been invalidated by the practice effect entailed, the subjects were divided at random into three groups and a system of rotating the material was introduced.

[13] (17) p. 117.
[14] (17) p. 438.

The test series for all groups consisted of forty stimuli. In Group I ten of these were selected at random from Series A, ten from Series B, and ten from Series C; in Group II, instead of the stimuli that had been selected from Series A for Group I, their counterparts from Series B were presented, and similarly cards from Series C and A were substituted for the stimuli corresponding to them in Series B and C respectively. In Group III, cards from Series C, A and B took the places of their counterparts in Series A, B and C respectively in Group I. For all three groups Series X constituted the remaining ten stimulus cards. This method of rotating the material for the three groups of subjects is made clearer by the following diagram:

Groups	*I*	*II*	*III*
Series	A	B	C
	B	C	A
	C	A	B
	X	X	X

c. Method of Equating Material for Different Groups of Subjects. The rotation of material assumed the equality of the material for all groups within a given series. In Series B the stimuli presented to Group I should bear the same degree of resemblance to their counterparts in the A series as those presented to the other two groups. Similarly the cards in Series C should have the same relationship to those of Series A for all groups of subjects. In order to test the validity of this assumption the subjects were asked to rate the cards according to degree of resemblance. At the close of the experiment each subject was given all the cards arranged in three sets following the order of the presentation series. He was asked to compare the cards in Series A with those in the other two. He was told to record a rating of "1" if the resemblance between the cards was as close as that between identical twins; "2" if they were as much alike as siblings; and "3" if they were no more alike than first cousins. The ratings of all the subjects within each of the three groups were averaged and the reliability of the differences between these averages was computed:

	Series B		Series C	
	Av.	$\sigma_{Av.}$	Av.	$\sigma_{Av.}$
I	1.37	.0282	2.64	.0310
II	1.37	.0291	2.67	.0526
III	1.56	.0289	2.64	.0270
D/σ_D	0.00		0.49	
D/σ_D	4.71		0.00	
D/σ_D	4.63		0.51	

With the exception of the average of Series B for Group III, the differences between the averages are unreliable, so that the assumption of the practical equality of the material for the different groups of subjects is confirmed. The cards of Series B that were presented to Group III showed on the average less resemblance to those corresponding to them in Series A than the stimuli of Series B that were presented to Groups I and II. This discrepancy, however, does not result in overlapping between the cards of this part of Series B and the corresponding cards of Series C. In fact intercomparisons among the three series show that we are justified in regarding them as wholly distinct, since the reliabilities of the differences are all extremely high. In computing the differences between A and B, A was assigned an arbitrary rating of "1" ± .00, as the result of an assumed comparison of A with itself. The differences betwen the series and their reliabilities are presented in the following table:

	A and B			*B and C*		
Groups	D	σ_D	D/σ_D	D	σ_D	D/σ_D
I	.37	.0282	13.121	1.27	.0418	30.382
II	.37	.0291	12.714	1.30	.0609	21.346
III	.56	.0289	19.377	1.08	.0395	27.342

3. *Apparatus*

The stimuli were presented by means of a Cattell spring tachistoscope with a wooden frame painted black, 40 by 37.5 cm. A shutter controlled by an electromagnet concealed an aperture 60 by 30 mm. in which the stimulus cards were inserted. The tachistoscope was connected with a stop watch which recorded the time to hundredths of a second and which was electrically operated by four 1.5 volt dry-cell batteries in series. Telegraph keys made contact with both the tachistoscope and the watch. Pressure on the experimenter's key closed the circuit through the electromagnet of the tachistoscope, which released the catch thereby allowing the spring rapidly to pull down the shutter and expose the stimulus. It was necessary to replace the shutter by hand.

In the presentation series, which did not involve response time, the watch was disconnected from the experimenter's key. The exposure time of the stimuli was regulated by a metronome set at 60 beats per minute. Two seconds were allowed

for each stimulus followed by a four-second interval. In the test series the tachistoscope was connected with the watch, so that pressure on the experimenter's key synchronously set both in motion. The watch stopped when the subject reacted by pressing either of two keys before him. A light visible to the experimenter and connected with the subject's right key indicated a positive reaction. Another contact through the experimenter's key returned the hand of the watch to the zero point.

The subject was seated at a table before the tachistoscope with his hands in position on the keys and his attention directed to the aperture where the stimulus was to appear. The illumination of the subject's field of view was kept constant by means of a 75-watt Daylight lamp so placed that its light fell directly on the aperture. The framework of the tachistoscope served to screen the experimenter's end of the table from the subject. The only source of illumination on the experimenter's side was a small carbon filament lamp of less than 4 c.p. which was shaded to prevent the light from being reflected to the subject's side.

The watch was calibrated by means of a Hipp chronoscope set up in an adjacent room. A bell metronome served as a signal to the observer. At the first bell stroke he assumed an attitude of readiness; at the second he started his apparatus; at the third he stopped. The reaction time lag was decreased by the rhythm and kept constant by having the same observer make all the reactions. The averages of ten reactions on both instruments were recorded in milliseconds:

Hipp	1836.5	A.D.	26.00
Watch	1840.0	A.D.	20.00
Difference	3.5	A.D.	00.32

The averages show that the two instruments agree, since the difference between them is unreliable. Moreover the average deviations show that successive reactions on either apparatus are reliable.

4. *Subjects*

The subjects were graduate and undergraduate students in the Department of Psychology, Columbia University. There were 108 in all, half men and half women. They were divided at random into three groups, each consisting of equal numbers of men and women. Since color plays so large a part in

the recognition of the material, the Ishihara test for color-blindness (18) was administered, and subjects whose color vision proved defective according to this test were eliminated. Moreover subjects with a language handicap were excluded because their scores on the Thorndike Vocabulary Test which was given in the interval between the presentation and test series would have been invalidated. The experiment was conducted individually, and required about fifty minutes.

5. *Procedure of the Experiment*

a. PRESENTATION SERIES. Before beginning the experiment, the subject was told that he was to be tested for ability to recognize designs and was advised to pay close attention to the stimuli in the presentation series so as to be able to recognize them later when mixed with others. He was given no warning of the confusing similarity among the cards that were to be encountered. At the ready signal the metronome was started. The thirty stimulus cards were then presented in an order determined by thorough shuffling and kept constant throughout the experiment.

b. INTERVAL. As soon as the presentation series had been completed, the subject was given a vocabulary test selected from the five highest levels of the Thorndike C. A. V. D. tests (44), on which he was allowed to work ten minutes. This task was set all subjects as a uniform means of distracting their attention from the main problem. The writer would have preferred to use samples of all the mental operations involved in the C. A. V. D. tests, but owing to the brevity of the interval this was impossible. Vocabulary was selected as the best single index of general intellectual capacity that could be obtained within the time limit. The scores on this test were later to be correlated with indices of redintegration.

c. TEST SERIES

(1) Method of Obtaining Recognition Time Scores

The subject was instructed to decide whether or not each stimulus had been shown in the original series. If he decided positively he was to react with his right key; if negatively, with his left. If in doubt, he was to guess. The forty test stimuli were then presented in an order which, like that of the presentation series, had been determined by shuffling and was kept constant throughout the experiment. In presenting

the stimuli the experimenter was guided by a key which indicated the order of the cards and also the series from which to select them for each of the three groups of subjects, according to the rotation plan previously described. Separate records were kept of the positive and the negative recognition times.

(2) Method of Obtaining Confidence Ratings

A method frequently used in previous studies to obtain confidence ratings was to require the subjects to express their confidence according to a certain arbitrary number of degrees, defined by such descriptive phrases as "sure," "fairly confident," "slightly certain," "mere guess." Subjective ratings of this sort, however, result in individual differences in interpretation. As we have already noted,[15] this difference is in part temperamental and in part due to "dividing a continuum into a series of compartments without objective aid or control." Few attempts to construct an objective scale have been reported. The work of Sumner (43) on belief in 1898 suggests a method. He drew up a set of twenty-five questions bearing upon nearly every class of subjects upon which the average person forms opinions. These questions were typewritten upon separate cards which the individual was requested to arrange in the order of the certainty with which he felt able to answer them. He found some evidence that "a graded arrangement of one's beliefs represents something real." Some of the possibilities in Sumner's questionnaire for the construction of an objective scale of confidence have already been realized by Strong (41), who has presented a scale which "extends from absolute belief (+100) through doubt (0) to absolute disbelief (—100)." He admits the imperfections of the scale inherent in the paucity of the subjects who supplied the statistical data on which it was based. The following is a sample of his scale:

Two plus two equal four	+99
There exists an all-wise Creator of the world	+73
A housefly has six feet	+47
The most honest man I know will be honest ten years from now	+21
Blessed are the meek for they shall inherit the earth	— 2
Magna Carta was signed in 1512	—22
It never rains but it pours	—53
Only the good die young	—74
Two plus two equal seven	—99

As regards the possible use to which this scale may be put,

[15] p. 6.

Strong says, "If one wishes to determine how strongly he believes that dark-haired girls are prettier than light-haired ones, he can compare it with the statements of the scale and so obtain a rating for it." Such ratings are better defined and more uniform for various subjects than the vaguer "degrees of confidence" previously used. A later attempt to construct a scale of confidence on the basis of Sumner's questionnaire was made independently by the present writer (12). Since the same degrees of confidence would occur in connection with questions that called for negative answers as with those whose answers were positive, the "negative" questions were eliminated as an unnecessary duplication. The remaining questions with the addition of an artificial zero point were then converted into statement form and arranged in descending order of certainty according to average positions. For convenience in handling, the series was then divided into a scale of six degrees with two propositions each as examples of the higher and lower extremes and three as examples of the vaguer middle degrees. By reference to this scale a subject could determine which statement best illustrated his degree of confidence in a given performance and thus give it a rating. Although this type of scale is an approximation of the objective measurement of confidence, it embodies several serious disadvantages. It was found cumbersome to use because the method of determining ratings was so indirect. Moreover, since it splits up a continuum into a number of steps, it does not remove the possibility of individual differences in interpretation of the various degrees, although to be sure these degrees have uniform definition.

In an attempt to obviate these difficulties which seem inherent in a verbal scale of confidence, a graphic method of rating confidence has been introduced in the present research. A five-inch line divided into a negative and positive half was used to represent the continuum of all possible gradations of confidence, ranging from a point 100 at the negative extreme, which indicated perfect confidence that a given stimulus had not occurred in the presentation series, to a point 100 at the positive extreme, which indicated perfect confidence that a given stimulus had previously been shown. The mid-point of the line, indicated by a zero mark, served to represent doubt. At the beginning of the test series the subject was provided with a set of forty copies of this scale, numbered to cor-

respond with the stimuli, with the instruction to check the point along the line which best expressed the degree of confidence he had in his recognition immediately after each reaction. A scoring stencil divided into ten parts numbered from one to ten was used to convert the various check marks into numerical scores.

III. RESULTS ON CONFIDENCE

1. *Individual Differences*

In Appendix I are presented the average ratings in confidence of each subject for the different situations. Intercomparison of these ratings reveals marked individual differences. Not only are there differences within the range of an individual's ratings for the various situations depending on the degree of completeness of data presented, but the general level of confidence is obviously higher for some subjects than for others. For example, the ratings of Subjects Br., Eth., Hl., Hg. among the men, and Mt., Wtr., As., Gu., Hil. among the women, represent a higher part of the scale than corresponding ratings of Subjects Dg., Ng., Ba., and Mac. among the men, and Dt., Grb., Cp., Dv., and Grg. among the women. Other subjects do not limit themselves to any particular part of the scale but use the entire range in making ratings.

Individual differences in confidence ratings are also demonstrated graphically in Charts I and II, which represent the distributions of all the ratings assigned by each subject. Confidence ratings are plotted along the X-axis, and the corresponding number of recognitions along the Y-axis. In the majority of cases there is a piling up of ratings at the upper extreme of the scale. This is especially conspicuous in figures numbered 1-24, 34, 35 and 36 (Chart I), and in those numbered 1-37 (Chart II). Other cases show bi-modal distributions, with higher frequencies at both extremes and a falling off in the middle ranges. Note especially figures 25, 30, 32 and 40 (Chart I) and 38, 39 and 41 (Chart II). Figure 46 (Chart II) is the only distribution showing the exclusive use of the central portion of the scale, while 47 alone illustrates a predominance of ratings at the lower extreme. The remaining quarter of the subjects distributed their ratings fairly evenly over the entire continuum.

2. *Sex Differences*

A survey of these charts seemed to show that the higher ratings of confidence occurred more frequently among the women than the men. To determine whether this represented a true sex difference in confidence rating, the total number of

CHART I

Frequency Distribution of Confidence Ratings—Men
by Individuals

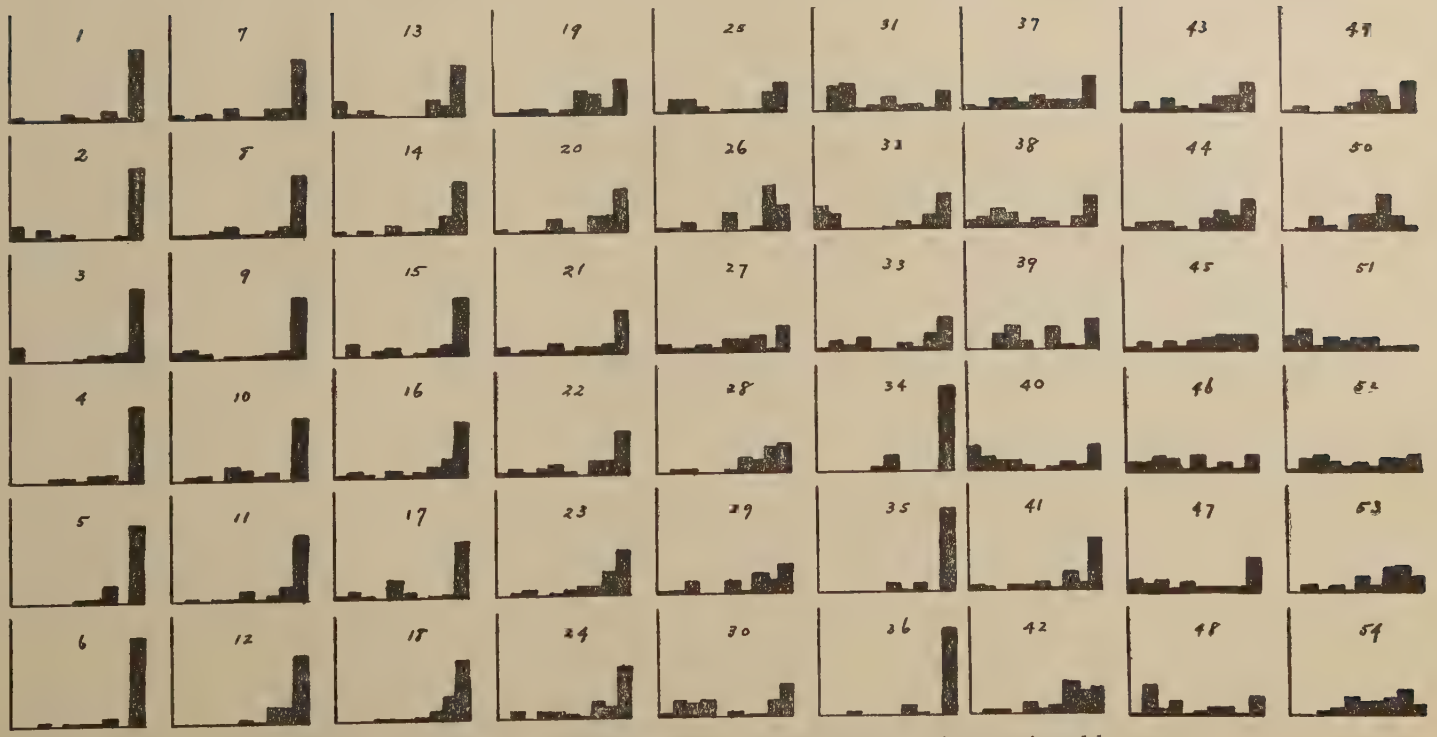


Chart I shows the distributions of all 40 confidence ratings assigned by the men subjects. The confidence ratings in percentages are plotted along the X-axis in steps of 10. The frequencies are plotted along the Y-axis, in steps of 5 up to the maximum of 40.

CHART II
Frequency Distribution of Confidence Ratings—Women
by Individuals

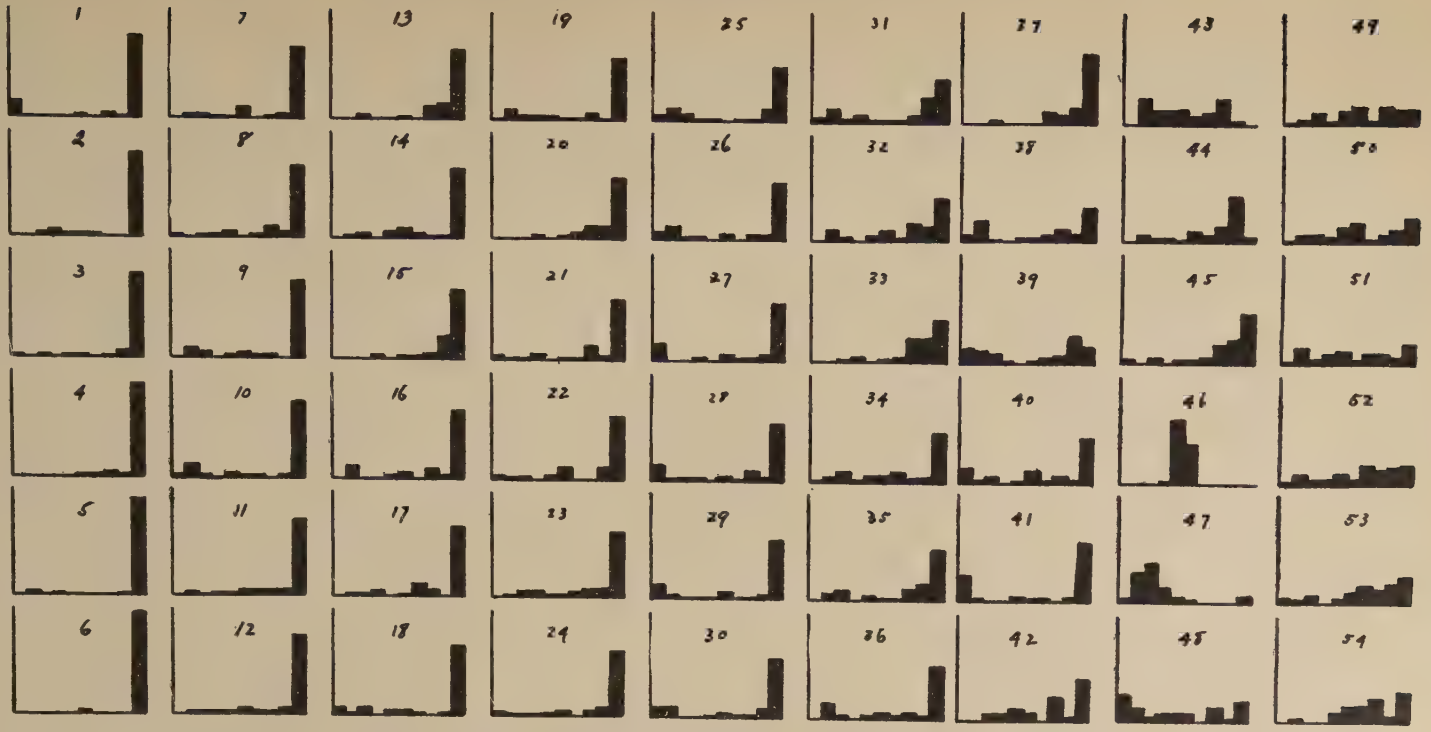


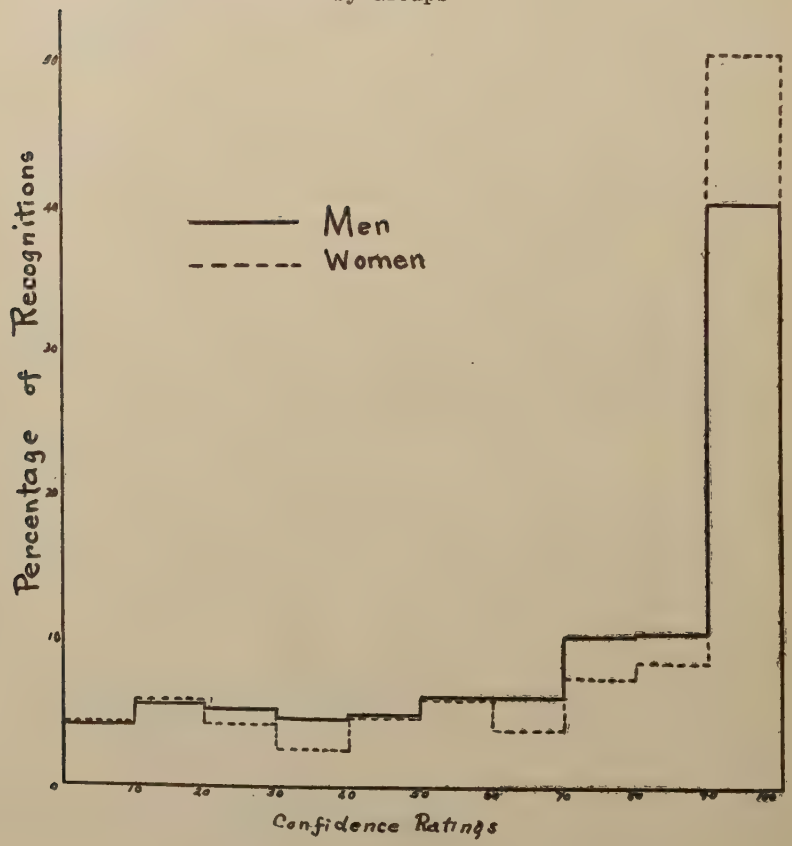
Chart II shows the distributions of all 40 confidence ratings assigned by the women subjects. The confidence ratings in percentages are plotted along the X-axis in steps of 10. The frequencies are plotted along the Y-axis, in steps of 5 up to the maximum of 40.

recognitions assigned the various confidence ratings was computed for men and women separately and a comparison of medians made.

	Men		*Women*
Median	81.22		90.25
Q	22.65		20.64
P. E.	0.618		0.555
D		9.03	
P. E.$_D$		0.823	
D/P. E.$_D$		10.969	

These results indicate a reliable sex difference showing that the women as a group assigned higher ratings of confidence than the men. This difference is brought out more strikingly in Chart III.

CHART III
Distribution of Confidence Ratings
by Groups



3. *Transmutation of Confidence Ratings*

The individual differences that we have noted in the absolute ratings assigned would render a direct comparison between individuals or a combination of the ratings of different individuals meaningless. These individual differences represent differences in subjective standards of confidence. This constituted the chief source of error of the earlier methods reviewed. But the graphic scale lends itself to a technic of equating the absolute ratings of various individuals which obviates this difficulty. The distribution of the ratings of a given subject was divided into ten parts. The ratings falling in the highest tenth of the distribution were given a final score of "1"; those in the next "2"; in the next "3"; and so on. On this basis, confidence ratings of judges who differed widely in absolute scores would receive equivalent final scores according to the relative positions of these ratings in the distributions.

When different confidence ratings were assigned to each of the recognitions the ten parts contained an equal number of ratings. It frequently happened, however, that the same rating was used for more than one recognition. If a strict division into ten equal parts was adhered to in such cases, identical ratings would frequently fall in different tenths. A method of transmuting scores which seemed better adapted to the data was to follow the natural cleavages of the distribution. As a concrete example, Subject Hd.'s distribution of confidence ratings with the corresponding transmuted scores are presented.

Confidence Rating	*Frequency*	*Transmuted Score*
100	17	1
85	5	2
82	1	2
80	3	3
78	1	3
75	1	4
70	2	4
68	1	5
66	1	5
62	1	6
60	1	6
54	1	7
52	1	7
40	1	8
28	1	9
20	1	10
10	1	10
	N = 40	

In this distribution, owing to the wide gap between the ratings 100 and 85, they were assigned to different intervals. Beginning with 85, the following ratings were given different transmuted scores by pairs until 40 was reached, which was so far apart from the preceding and following ratings as to warrant a separate transmuted score. The question next arose as to the fairest way of grouping the remaining three ratings. Two alternatives presented themselves, either to place 28 and 20 together, letting 10 alone represent the lowest division, or to put 10 and 20 togther at the lower extreme and give 28 a separate transmuted score. We decided on the latter procedure, since 25 is usually regarded as a critical point differentiating a negligible from an appreciable degree of confidence. This distribution illustrates cases in which the same confidence rating was assigned to several recognitions. In the majority of such cases the confidence ratings having these high frequencies were in the upper extreme of the scale, as in the example we have analyzed. As a result, the higher intervals are more largely represented in a given subject's transmuted scores.

There were a very few atypical distributions in which fewer than ten different confidence ratings were used, so that fractional scores had to be assigned in their transmutation. These scores were determined by dividing ten by the number of ratings. The quotient constituted the first transmuted score, and by adding that amount as a constant increment starting with this first score we derived the others.

IV. RESULTS ON RECOGNITION TIME

1. *Comparison of Recognition Times with Other Reaction Time Measures*

Although the aim of the present research was to use recognition time merely as an instrument in the study of confidence, it is interesting for its own sake and in comparison with reaction time in various other situations. The entire range of recognition times extended from .30 to 60.00 seconds, with the median for men at 1.51 and that for women at 1.57 seconds. A more detailed analysis of recognition times may be obtained from Appendix II in which the average raw scores for each subject in the different situations are presented. It is interesting to compare recognition time scores with the following list of simple reaction times expressed in milliseconds given by Woodworth and Poffenberger (51).[16]

Touch	110-160
Sound	120-160
Sight	150-200
Cold	150
Warmth	180
Smell	200-800
Taste	300-1000
Pain	400-1000

As for discrimination reactions, Ladd and Woodworth (22)[17] find that the discriminative reaction is in part a measure of the perfection of the preparation to react to the stimulus and in part a measure of the difficulty of the discrimination involved. With regard to the preparation they cite Merkel's work on the number of movements held in readiness to be executed each in response to an assigned stimulus. The reaction times vary from 188 milliseconds for one movement (simple reaction to visual stimulus) to 588 for choice among ten movements. With regard to the difficulty they cite Henmon's (11) study in distinguishing colors, which showed increases in time from 197 milliseconds when black was to be distinguished from white, to 271 when red was to be distinguished from orange mixed with 75% red. A recent experiment on difficulty of discrimination is that of Lemmon (21) in which the subject was to distinguish between various numbers of lights. The reaction times varied from 290 milliseconds in the

[16] p. 184.
[17] p. 489-490.

case of discrimination between no light and one light, to 741 when four lights were to be distinguished from five. More complex reactions involved in association range between 700 and 1400 milliseconds, according to Myers (30).[18] Woodworth and Wells (52)[19] tabulate the reaction time of the different forms of controlled association as follows:

Performance	*Time in Seconds Per Single Reaction*	*P. E.*
Reading letters or short words	0.33	
Naming colors	0.61	.03
Naming forms	0.89	.09
Adding 2 one-place numbers	1.07	.08
Easiest opposites	1.11	.04
Agent-action	1.30	.03
Verb-object (easiest)	1.31	.05
Adding 4 (constant increment test)	1.36	.08
Part-whole	1.53	.06
Attribute-substance	1.53	.06
Supraordinate-concept	1.54	.07
Action-agent	1.55	.07
Whole-part	1.57	.07
Subtracting 4 (constant increment test)	1.53	.07
Subordinate-concept	1.84	.07
Mixed relations	3.14	.13
Adding 17 (constant increment test)	3.90	.31

A still more complex mental process has been measured by Martin (25) in his work on voluntary choice. When the subject was required to choose the more agreeable of two odors, the average time for the main period was 5.49 seconds, and when the task was the choice of two alternatives to solve a dilemma the average time was 36.33 seconds. If recognition time may be regarded as a criterion of the difficulty of the task, a comparison of the speed of recognition with reaction times in these other situations seems to indicate that the recognitions studied in this experiment were more difficult than simple discrimination but less difficult than voluntary choice. A number of sporadic cases, however, running beyond average voluntary choice times are really directly comparable with such choice reactions since they seemed to involve deliberation. The median recognition times correspond most closely to the middle range of controlled association times, represented by part-whole, attribute-substance, subordinate-concept, action-agent and whole-part associations. They are slower than the simpler associations of reading letters or

[18] p. 134.
[19] p. 66.

CHART IV
Distribution of Recognition Time Scores—Men

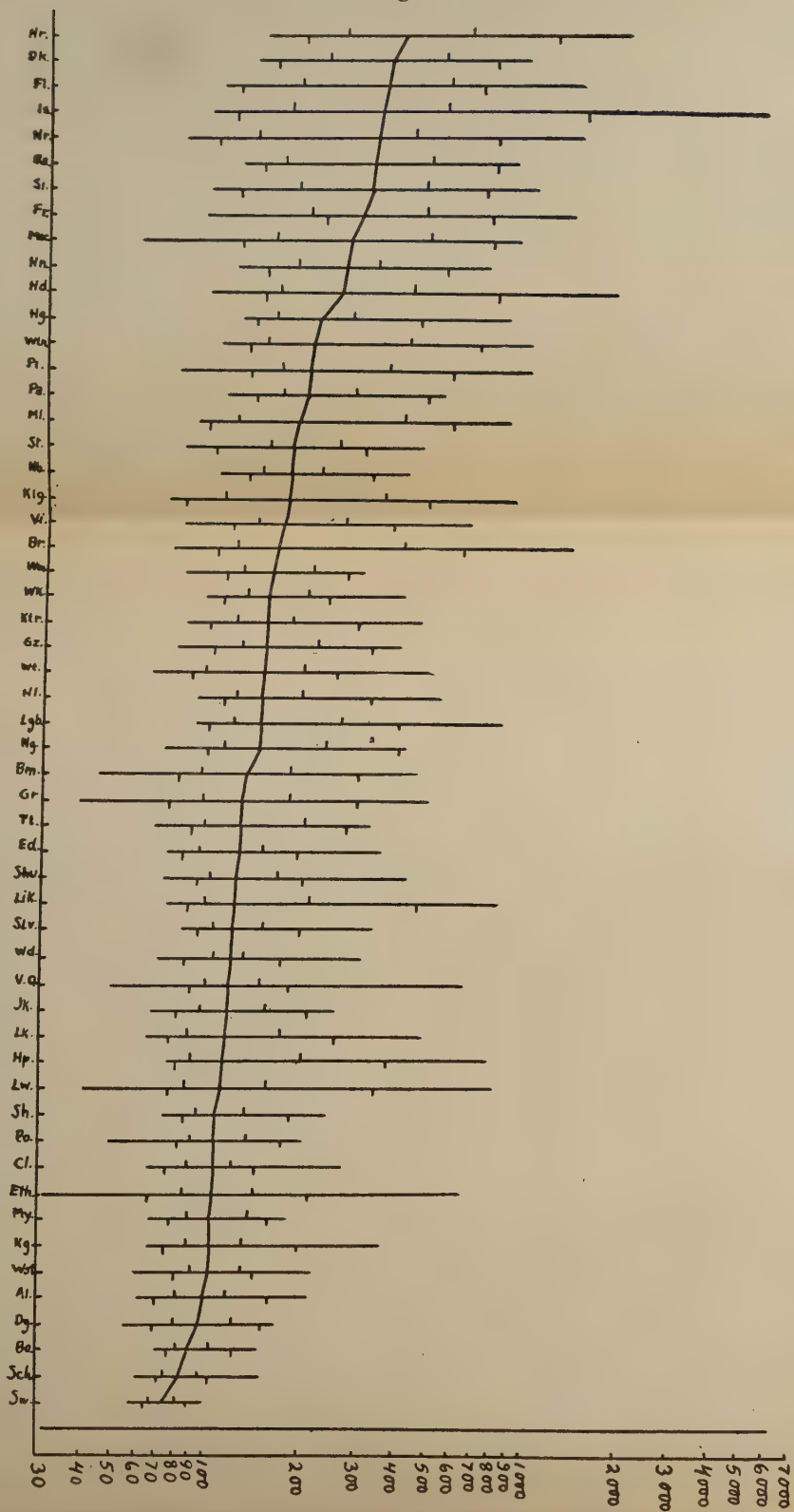
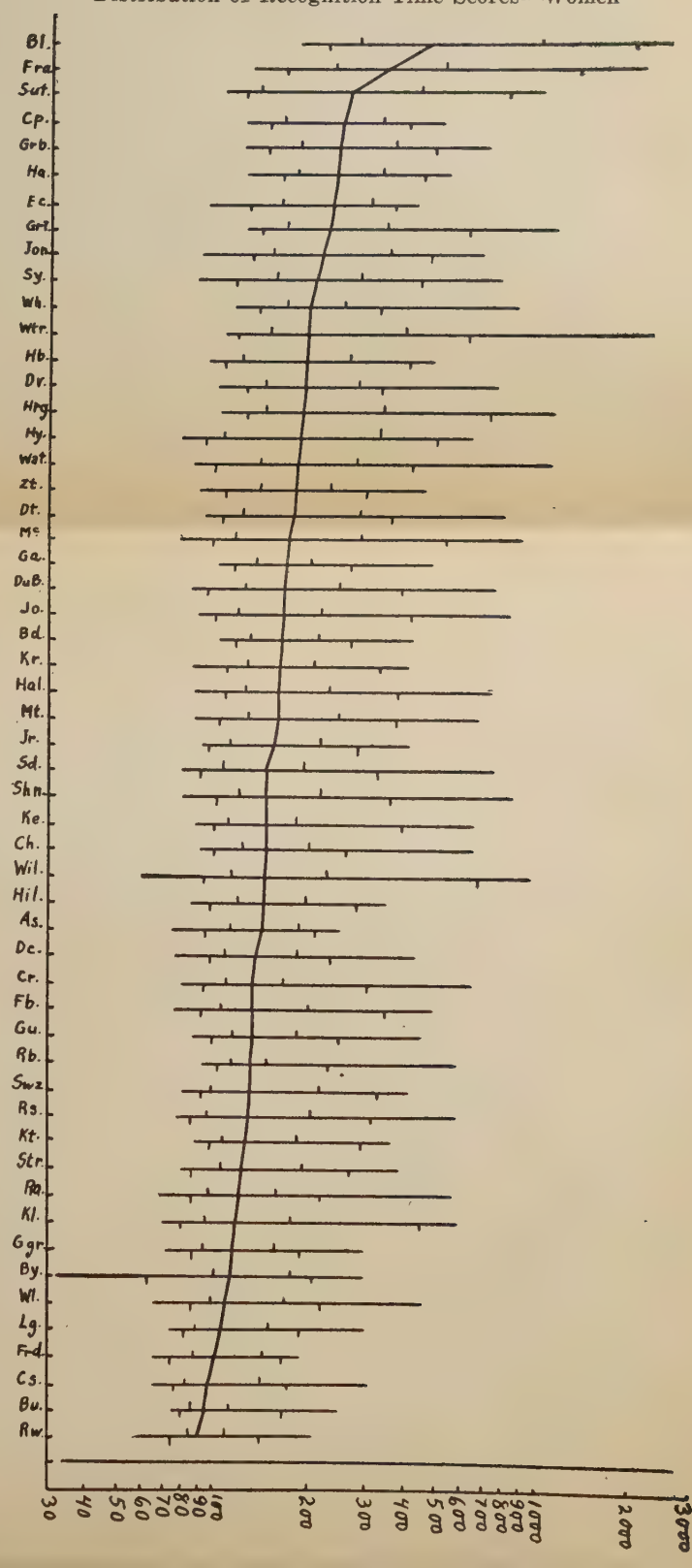


CHART V
Distribution of Recognition Time Scores—Women



short words, naming colors and forms, etc. Such associations do involve recognition but recognition of a simpler nature, because on a more purely perceptual level. On the other hand, recognition time is appreciably faster than the time required for the most difficult forms of controlled association shown in mixed relations and adding 17. These processes go beyond recognition in complexity.

2. *Individual Differences in Recognition Time*

Examination of Appendix II reveals striking individual differences in absolute recognition time scores. Subjects Dg., Sch., Sw., Wst., Bo. among the men, and Bu., Rw., Cs., and Gg. among the women, consistently made faster scores than the group medians, while Subjects Ba., Hd., Hg., Hr., Hn., Sl., Dk., Tl., Fr. and Is. among the men, and Bl., Grb., Ha., Cp., Fra., Grt. and Hrg. among the women were slower than the group medians.

When the total range in recognition times is analysed, we find further evidence of individual differences, as Charts IV and V indicate. The graphs have been plotted on logarithmic paper to avoid giving disproportionate weight to the atypically high scores. The individual distributions are arranged according to the size of the medians. The small upward vertical marks on each side of the medians represent the upper and lower quartiles. The downward vertical marks located further toward the left and right extremes indicate respectively the 10th and 90th percentiles. Inspection shows that the men vary in median score from .74 seconds to 4.23 seconds, while the quickest median recognition time for the women is .90 and the slowest 5.02. Comparing individuals for total range, we find that the shortest range for the men extends from .60 to 1.00, while the longest extends from 1.00 to 63.74. Among the women the shortest range is between .67 and 1.91; the longest between 1.09 and 23.93. A tendency may be observed for the subjects with the shortest medians to have the shortest ranges, while the subjects whose medians are long distribute their responses over a wide range. This inverse relationship between median speed of recognition and total range seems to indicate that the subjects whose medians are shortest are consistently prompt in their responses, while slow medians are accompanied by greater variability in recognition time. To obtain more exact measures of variability, coefficients of

relative variability (Pearson)[20] were computed for each subject and are presented in Table I. Intercomparison reveals a wide range of individual differences. The least variable subject is only .06 as variable as the most. The least variable man is .12 as variable as the most variable man, and the least variable woman is .07 as variable as the most variable woman.

3. *Sex Differences in Recognition Time*

Comparing the median recognition times of the men and woman as groups, we find:

Recognition Time Scores (in hundredths of a second)		
	Men	*Women*
Mdn.	151	157
P.E.mdn.	8.06	5.44
D.		6.00
P.E./$_D$		9.73
D./P.E.$_D$		0.62

Coefficients of Relative Variability		
	Men	*Women*
Mdn.	30.6	32.4
Q.	12.4	6.3
P.E.mdn.	2.11	1.07
D.		1.80
P.E./$_D$		2.37
D./P.E.$_D$		0.76

From these results we must conclude that there is no reliable sex difference in recognition time. Moreover with regard to the relative variability of the individuals comprising the sex groups, we are forced to a similar conclusion. That is, the responses of the individual man appear to be no more variable around his own median than those of the individual woman around her median.

4. *Transmutation of Recognition Time Scores*

Analysis of the individual distributions reveals a positive skewness. In the case of a given subject the responses tend to be massed toward the faster extreme approaching the physiological limit. A similar piling up of cases toward the high end of the confidence scale was previously noted.[21] Apparently, then, the conditions of this experiment were conducive to quick confident reactions. The set-up of the experiment with the apparatus for recording reaction time may well have given the subject a mental set toward speed. The high ratings of confidence may be explained by the fact that the subject was ignorant of the similarity among the series of stimuli and therefore reacted without the hesitation which would have arisen from awareness of the possible confusion. This confi-

[20] $V = \frac{Q}{Mdn} \times 100.$

[21] p. 25.

TABLE I

Coefficients of Relative Variability. $\left(V = \frac{Q.}{Mdn.} \times 100\right)$

Men						*Women*					
Group I		*Group II*		*Group III*		*Group I*		*Group II*		*Group III*	
Br.	89.7	Ba.	51.3	Al.	19.4	Bl.	75.7	By.	32.5	As.	25.8
Dg.	23.3	Eth.	26.0	Bo.	13.7	Bd.	25.0	Ch.	26.8	Cp.	34.4
Ed.	21.1	Gz.	31.9	Brn.	33.6	Bu.	14.0	Cr.	20.8	Cs.	28.5
Hp.	49.7	Hd.	53.7	Cl.	12.7	Dt.	44.8	Dc.	27.9	Dv.	35.4
Ktr.	20.5	Hal.	26.0	Dk.	44.1	DuB.	37.9	Frd.	28.7	Fra.	42.1
Lik.	47.4	Hg.	28.6	Fl.	54.2	Ec.	32.3	Grb.	38.3	Ggr.	27.4
Ng.	43.8	Hr.	51.0	Fr.	47.9	Fb.	34.3	Ha.	32.4	Grt.	38.6
Pa.	30.1	Hn.	29.4	Gr.	33.8	Ga.	18.8	Hy.	61.5	Gu.	25.6
Sch.	12.7	Klg.	15.7	Is.	56.0	Jo.	29.6	Jr.	34.3	Hal.	33.5
Sw.	34.5	Kg.	22.0	Jk.	25.9	Ke.	24.1	Kr.	24.0	Hrg.	52.5
Sh.	18.8	Lgb.	51.1	Lk.	36.7	Kt.	29.9	Mc.	50.4	Hil.	25.3
Slv.	20.1	Nb.	22.9	Mac.	63.1	Lg.	28.7	Mt.	38.5	Hb.	37.3
Tt.	42.3	Po.	20.6	Ml.	78.0	Ra.	25.6	Rs.	41.5	Jon.	46.3
V.O.	20.2	St.	29.3	My.	25.0	Sd.	28.6	Rw.	14.7	Kl.	33.8
Vi.	38.0	Shu.	26.6	Nr.	44.9	Swz.	45.4	St.	35.6	Rb.	12.1
Wst.	19.3	Su.	45.3	Pi.	52.0	Wat.	38.1	Sut.	58.6	Shu.	33.1
Wk.	22.7	Wtn.	68.3	Wm.	26.8	Wil.	05.3	Wtr.	62.8	Sy.	32.2
Wd.	10.7	Lw.	31.0	Wt.	33.9	Zt.	25.6	Wl.	33.1	Wh.	21.4

dent attitude would cooperate with the general mental set toward speed to accelerate his responses. Sporadic delayed responses, however, extend the subject's range disproportionately beyond his central tendency. Since there is no limit at this upper end of the distribution, a wide scope was given to individual differences. These atypically long reactions, varying from one subject to another, would unduly weight averages obtained directly from the raw scores of the different subjects. In order to avoid this the recognition time scores were re-evaluated according to the method used in equating individual differences in confidence ratings. Since very few duplications of recognition times occurred, the ten intervals into which the distribution was divided usually contained an equal number of scores. Thus in a given subject's transmuted scores the upper and lower divisions were equally represented.

V. RECOGNITION TIME AND CONFIDENCE RELATED TO DEGREE OF COMPLETENESS OF DATA

1. *Comparison of Recognition Time Scores and Confidence Ratings in the Various Situations.*

In order to determine to what extent confidence and recognition speed varied according to the completeness of the data, average transmuted scores for the various situations were compared. Inspection of Table II, which presents the average transmuted scores for the various situations, shows that when the responses are positive, decreasing degrees of completeness of data are accompanied by progressive decreases in speed of recognition. Conversely, in the "negative" cases decreases in speed occur in situations of increasing degree of completeness. Corresponding changes in confidence ratings may be observed to accompany these changes in recognition time.

TABLE II

Average Transmuted Scores in Recognition Time and Confidence

	Degree of Completeness of Data							
	Positive Reactions				*Negative Reactions*			
	A	*B*	*C*	*X*	*X*	*C*	*B*	*A*
R. T. ...	4.88	5.40	6.18	6.16	4.36	5.41	6.41	6.33
σ av. ...	.0931	.1190	.1714	.3027	.0847	.0972	.1275	.1476
Conf. ..	3.66	4.34	5.66	7.38	2.90	4.01	4.99	5.20
σ av. ...	.1067	.1281	.1919	.2952	.0820	.1071	.1398	.1765
N.	765	580	292	84	996	788	500	315

From another viewpoint, variations in completeness of data indicate variations in accuracy. In the simple recognition experiment, where the presentation and test stimuli are either the same or altogether different, a response may be regarded as right or wrong, but this all or none treatment is obviously not adaptable to situations in which the test stimuli bear varying degrees of likeness to those of the presentation series. In such situations gradations of accuracy should be admitted. As the resemblance between the presentation and the test stimuli approaches identity the positive responses become increasingly more accurate and the negative responses increasingly more inaccurate. On this basis we find that decreases in degree of accuracy are accompanied by decreases in recognition speed and confidence. Charts VI and VII present this relationship

graphically for the positive and negative reactions respectively. The situations in which the various degrees of correctness occur are plotted along the abscissa, while transmuted scores appear along the ordinate. This finding is in keeping with the results of previous investigators who found accuracy correlated with speed and confidence.

CHART VI

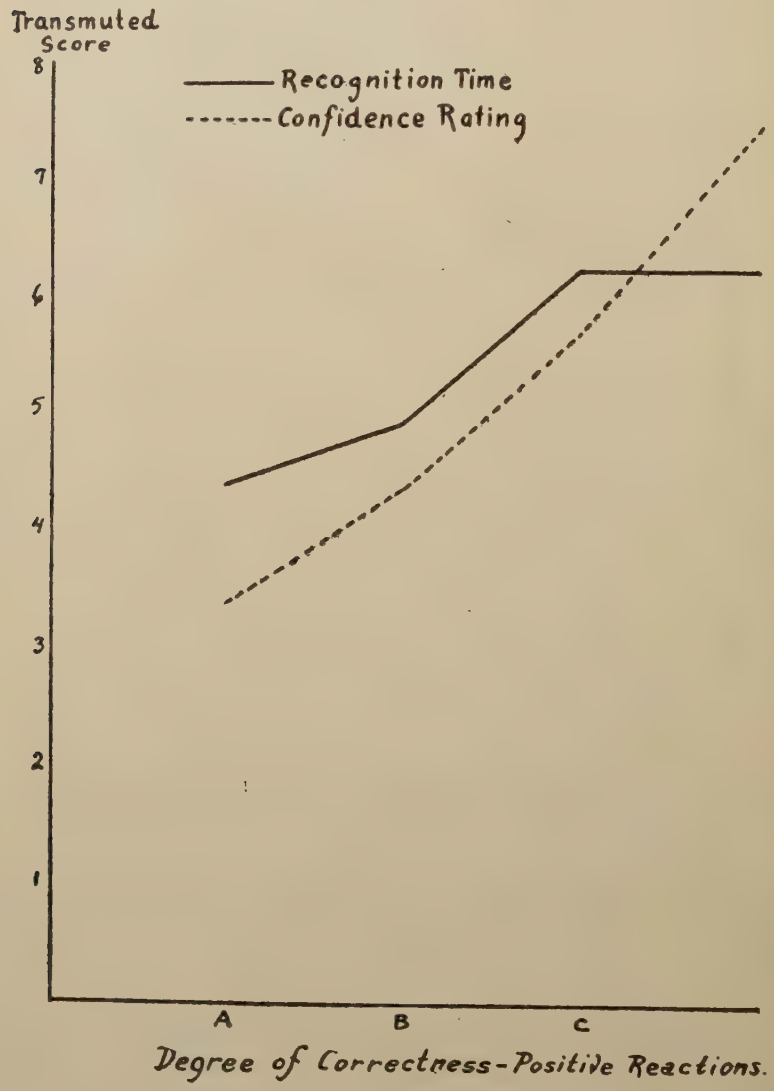


CHART VII

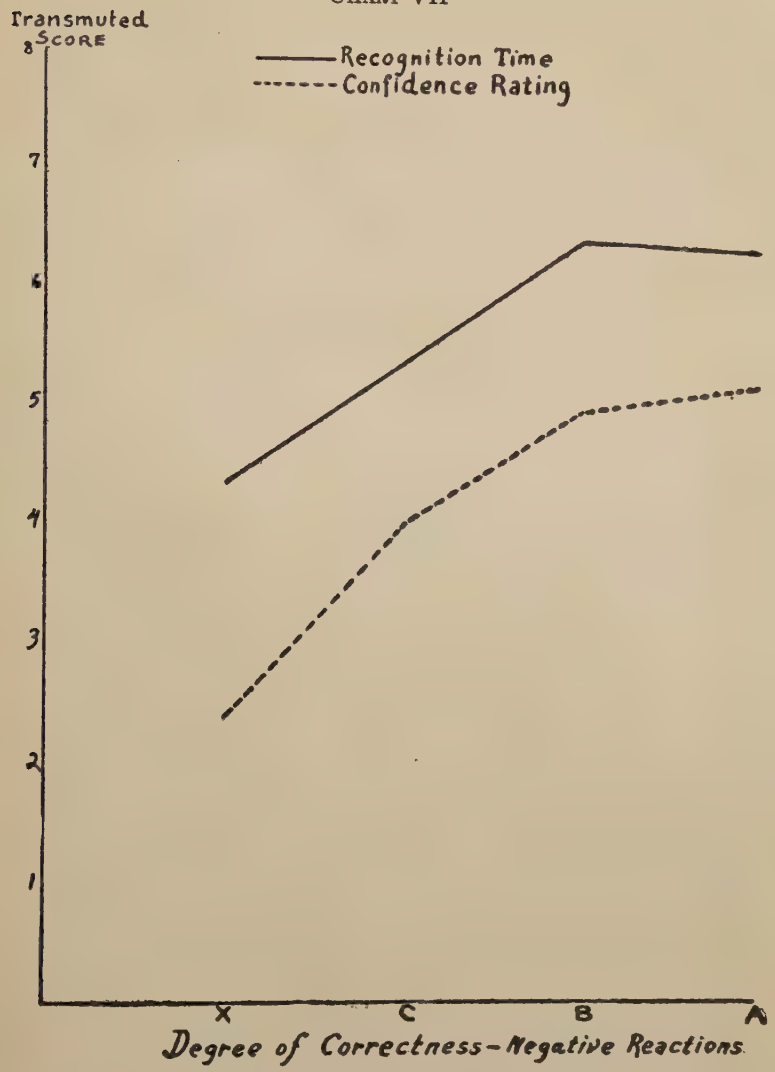


Table III shows that the differences we have noted are highly reliable for the most part and therefore represent a real tendency. There is an apparent discrepancy, however, in the case of the average recognition speed of the positive reactions in Series X, since it fails to show the expected decrease over that of Series C. An analogous discrepancy appears in the unreliability of the differences in recognition time and confidence between the negative responses of Series A and B. This

TABLE III

Differences and Their Reliabilities, between Averages*

	1. Recognition Speed					
	Positive Responses			*Negative Responses*		
	D	σ_D	D/σ_D	D	σ_D	D/σ_D
A-B	—0.52	.1499	3.47	—0.08	.1950	0.41
A-C	—1.30	.1941	6.70	+0.92	.1767	5.21
A-X	—1.28	.3161	4.05	+0.97	.1701	11.58
B-C	—0.78	.2277	3.43	+1.00	.1603	6.92
B-X	—0.76	.3252	2.34	+2.05	.1530	13.40
C-X	+0.02	.3478	0.06	+1.05	.1289	8.15
	2. Confidence					
A-B	—0.68	.1667	4.08	+0.21	.2251	0.93
A-C	—2.00	.4700	4.26	+1.19	.2064	5.77
A-X	—3.72	.3138	11.85	+2.30	.1946	11.82
B-C	—1.32	.4753	2.78	+0.98	.1761	5.57
B-X	—3.04	.3217	9.45	+2.09	.1620	12.90
C-X	—1.72	.5446	3.16	+1.11	.1348	8.23

seems to indicate that recognition speed and confidence decrease as the situation becomes more difficult but only up to a certain point beyond which further increase in difficulty does not produce proportionate lowering of the scores. This tendency is clearly shown in Charts VI and VII in the flattening out of the curves at the upper extreme, except in the curve for positive confidence ratings, which apparently had not reached the maximum point.

2. *Comparison of Positive and Negative Reactions*

Table IV enables us to make a comparison between positive and negative reactions which brings out clearly the relationship of speed and confidence. We find that in the A situation, in which negative responses may be regarded as most incor-

TABLE IV

Comparison of Positive and Negative Responses

	Recognition Speed			*Confidence*		
	D	σ_D	D/σ_D	D	σ_D	D/σ_D
A(+) — A(—)	—1.45	.1735	8.36	—1.54	.2062	7.47
B(+) — B(—)	—1.01	.1744	5.79	—0.65	.4753	1.37
C(+) — C(—)	+0.77	.1970	3.91	+1.65	.4701	3.51
X(+) — X(—)	+1.80	.3143	5.73	+4.48	.3063	14.63
A(+) — X(—)	+0.52	.1244	4.18	+0.76	.1346	5.65
A(—) — X(+)	+0.17	.3367	0.50	—2.18	.3439	6.34

*Note: a + sign indicates an increase, a — sign a decrease, from the first to the second member of a pair.

rect and positive responses as most correct, the negative responses are slower and less confident than the corresponding positive responses. In the B situation, in which the same relations between negative and positive reactions hold, but to a lesser degree, the same tendency is operative, but to a lesser degree. Series C and X present results that are analogous but opposite in direction, because here the negative responses are more correct than the positive ones. When the most accurate positive reaction (A+) is compared with the most accurate negative reaction (X—), we find a reliable difference which indicates increased speed and confidence for the negative reaction. The converse does not hold in the case of the recognition time of the most inaccurate reaction because of the low recognition time that we have already noted for the positive reactions in the X situation, but it is apparent in the confidence rating for this situation. From these results it appears that the more accurate response is quicker and more confident than the more inaccurate regardless of whether it is positive or negative, but that when two responses are equally accurate the negative is the faster and more confident. This finding gives experimental confirmation to Strong's statement: "It seems, then, that the ability to know we have not seen an object is much more firmly fixed than the ability to pick out what we have seen."[22] It is also partly in keeping with the results of Wylie's (53) study in which higher confidence accompanied the recognition of new stimuli as new, than of old as old. She also found, however, that the reactions for the old as old were shorter than for the new as new.

3. *Coefficients of Correlation between Recognition Time and Confidence*

We have seen that variations in recognition time accompany variations in confidence according to the degree of completeness of the data. A more exact measure of the relationship between recognition time and confidence may be obtained by the correlation technic. A random sampling of the material was secured by selecting the data of every fifth subject and correlating his raw recognition time scores with his confidence ratings by means of the Pearson Product Moment method. It was considered justifiable to lump the results of all four de-

[22] (39) p. 372.

grees of resemblance together because the general speed and confidence of recognition in practical situations is based on data which varies in compelteness. In Table V the correlations are

TABLE V

Coefficients of Correlation (Pearson) between Recognition Time and Confidence

Subject	*r.*	*P.E.*	*Subject*	*r.*	*P.E.*
Fl.	+.37	±.0914	Nb.	+.66	±.0598
Kl.	+.37	±.0914	Al.	+.68	±.0569
Dv.	+.44	±.0854	Kr.	+.68	±.0569
Wd.	+.46	±.0835	Pa.	+.69	±.0555
Hr.	+.47	±.0825	Tt.	+.72	±.0510
Ed.	+.50	±.0800	Kt.	+.73	±.0495
Lk.	+.51	±.0784	Eth.	+.75	±.0467
Ec.	+.55	±.0738	Stk.	+.76	±.0447
Wat.	+.61	±.0665	Bl.	+.76	±.0447
Frd.	+.63	±.0639	Wtn.	+.78	±.0404
Ha.	+.64	±.0625	Pa.	+.81	±.0364

presented in the order of magnitude. It will be observed that the correlations range from +.37 ±.09 to +.81 ±.04, with the median at +.65 ±.06. These results indicate a definite relation between recognition time and confidence since all the correlations are positive and, according to their probable errors, reliable. This relation, however, is not sufficiently close to allow us to regard recognition time as a measure of confidence in a strict statistical sense, since it could not justifiably be used in a regression equation from which to predict confidence ratings. Confidence apparently is not the sole determinant of speed of recognition, nor, conversely, is speed the sole determinant of confidence. We can, therefore, regard speed as only a partial indicator of confidence.

VI. SPEED, CONFIDENCE AND FREQUENCY OF RECOGNITION AS INDICES OF REDINTEGRATIVE BEHAVIOR

In the preceding section, we found that regular increases in speed and confidence accompany increases in completeness of data. This confirms the assumption made in the beginning, that speed and confidence were indicators of redintegrative behavior. We may also consider frequency of positive reactions as a measure of the redintegrative tendency, since it also varies with the degree of completeness of the data:

	Frequency	D_{A-B}	D_{B-C}	D_{C-X}	σ_D	D/σ_D
A	70.83					
		17.13			2.58	6.64
B	53.70					
			26.67		2.39	11.15
C	27.03					
				19.26	1.70	11.30
X	07.77					

The differences in tendency to redintegrate elicited in these four situations are large and highly reliable. Moreover they are strikingly uniform, approximating 20% in all cases.

We have next attempted to discover whether these differences in redintegrative tendency are qualitative as well as quantitative. In order to do this we determined to what extent the tendency toward redintegrative behavior in one situation would serve to indicate a similar tendency in another situation. Since individual differences in recognition memory would conceal differences in redintegrative tendency, the memory factor had to be discounted in computing measures of redintegrative tendency for the various subjects. Regarding the positive reactions in situation A as representing recognition memory, we have used as indices of redintegrative behavior the ratios which the positive responses in situations B, C and X bear to the positive responses in situation A. The relationship between the various situations with regard to redintegrative behavior is expressed by Yule's Coefficient of Association,[23] with the following results:

[23] $Q = \frac{(++)(--) - (+-)(-+)}{(++)(--) + (+-)(-+)}$

	Men	*Women*
B—C	—.22	+.35
B—X	+.29	+.59
C—X	+.29	+.69

Since the Coefficient of Association is somewhat higher than the Pearson Coefficient of Correlation, the relationships between the various situations are not sufficiently close to warrant prediction from one to another. This apparent difference in type of redintegrative response may be partly accounted for by differences in sagacity expressed in the various situations. A response is "sagacious" when it results from discrimination between details which are relevant to the present context and those which are irrelevant. For example, if we mistake a scarecrow for a man our response lacks sagacity and we are the subject of illusion. In the test situation, positive responses to stimuli of Series B, C and X indicate progressively less sagacity because of the increasing irrelevance of the instigating details. The negative reactions in these situations, on the other hand, do exhibit adequate sagacity. The positive responses may indicate that flexibility of neural connections which underlies ease of learning. Hollingworth (17)[24] finds the fact of learning inadequate to describe intelligence unless sagacity is also taken into account. On this basis subjects in whom the ease of learning factor is accompanied by the least sagacity, such as those who make positive responses in situation X, would be expected to demonstrate less intelligence than corresponding subjects for C and still less than those for B. As an experimental check on this hypothesis Pearson coefficients of correlation were computed between indices of redintegration and the Thorndike vocabulary test, for situations B, C and X. The results are as follows:

	r.	*P.E.*
B	—.37	±.06
C	+.39	±.05
X	+.01	±.06

The correlations for C and X show the expected tendency, but that for B is obviously discrepant both as to magnitude and direction, so that we cannot regard these results as con-

[24] p. 470.

firmative of our hypothesis. This aspect of the problem demands further investigation.

Table VI summarizes the data on speed, confidence and frequency in the various situations according to decreasing order.

TABLE VI

	X—	*C*—	*A*+	*B*+	*B*—	*A*—	*C*+	*X*+
Frequency	92	73	71	54	46	29	27	08
Confidence	2.90	4.01	3.66	4.34	4.99	5.20	5.66	7.38
Recognition Speed	4.36	5.41	4.88	5.40	6.41	6.33	6.18	6.16

It will be observed that frequency, confidence and speed agree fairly closely in indicating the redintegrative tendency. It is clear that all three measures give the X— responses the most favored position; they are the quickest, the most confident and the most dependable. It would seem therefore that the tendency to non-redintegrative reactions to new objects is not to be regarded as a mere absence of the redintegrative or recognitive response. It seems, rather, to be a counter-tendency which depends largely on the factor of discrimination between details which are relevant to the present context and those which are irrelevant. Since there is practically no similarity between the stimuli in situation X and those of the presentation series, there is little danger of confusion and discrimination is simple.

The A+ and C— responses are nearly equal by all three measures. Thus it might seem that the counter-tendency even when the stimulus affords some basis for redintegrative response is as strong as the redintegrative tendency when the stimulus affords the maximum ground for the redintegrative response. Similarly, the C+ and A— responses are very nearly equal by all three measures. Here it would seem that the tendency to redintegrate when the stimulus affords the "amount of data" represented by C+ is equal to the counter-redintegrative tendency acting against complete data. A+, however, cannot be directly compared with C—, nor C+ with A—, because the negative responses cannot all be attributed to the counter-redintegrative tendency. In many cases the C— responses may be due to forgetting. Thus the redintegrative tendency in the A+ situations is balanced by both forgetting and the counter-redintegrative tendency. The C+ situation, on the other hand, in which the redintegrative tendency is manifested in lesser degree, is balanced by the A— responses which are largely the result of forgetting alone.

As for the B situation, the three measures are in agreement in giving the positive and negative responses a middle position, showing a balancing of the factors involved in them, with a slight advantage for the positive tendency.

An adequate analysis of the factors involved in the positive and negative responses in the various situations should be based on introspective experimentation.

VII. SUMMARY.

In this research an attempt was made to determine the extent to which speed of redintegrative response might serve as an index of confidence. A recognition experiment was set up in which the material of the test series bore different degrees of resemblance to that of the presentation series. The subject's recognition times were recorded in hundredths of a second and his confidence ratings obtained from a graphic scale. Recognition time and confidence were compared for the various situations and coefficients of correlation between recognition time and confidence computed.

The chief results of this experiment may be summarized as follows:

1. There are marked individual differences in confidence ratings. Some subjects prefer the upper extreme of the scale, others use both the upper and lower extremes, while still others distribute their ratings fairly evenly over the entire continuum. In the majority of cases there is a piling up of ratings at the upper extreme.

2. The women as a group make higher confidence ratings than the men.

3. The total range of recognition times extends from .30 to 60.00 seconds, with the median for men at 1.51 and that for women at 1.57 seconds. Compared with other reaction time measures, the median recognition times correspond most closely to the middle range of controlled association times.

4. There are marked individual differences in recognition time with regard to both median and total range. The men vary in median score from .74 seconds to 4.23 seconds; the women, from .90 to 5.02 seconds. With regard to individual total range, the shortest range for the men is between .60 and 1.00 seconds, the longest between 1.00 and 63.74; for women, the shortest is between .67 and 1.91, the longest between 1.09 and 23.93. An inverse relationship between median speed of recognition and total range was observed.

5. There are marked individual differences in variability indicated by coefficients of relative variabilty.

6. There are no reliable sex differences in either speed or relative variability of recognition times.

7. When the responses are positive, decreasing degrees of completeness of data (accuracy) are accompanied by progressive decreases in speed and confidence of recogntion. Conversely, in the "negative" cases decreases in speed and confidence occur in situations of increasing degrees of completeness. This tendency, however, is found to hold only up to a certain point beyond which further increase in difficulty does not result in proportionate lowering of the scores.

8. The more accurate response is found to be quicker and more confident than the more inaccurate regardless of whether it is positive or negative, but when the two responses are equally accurate the negative is found to be the faster and more confident.

9. Coefficients of correlation between recognition time and confidence range from $+.37 \pm .09$ to $+.81 \pm .04$ for the separate individuals. Although these correlations indicate that recognition time and confidence are positively related, they are not sufficiently high to warrant the use of recognition time as an exact measure of confidence.

Regarding the recognitive process as illustrative of the general laws of redintegration, the results for positive reactions showing that variations in completeness of data are accompanied by variations in speed and confidence indicate variations in redintegrative response. Frequency of recognition may be regarded as a further indication of this tendency. The positive responses have been regarded as indicating the redintegrative tendency. The negative responses on the other hand may represent a counter-redintegrative tendency largely involving the sagacity factor, or they may be simply the result of forgetting. Introspective study is necessary to confirm these speculations.

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APPENDIX I

Average Raw Scores in Confidence

	Positive Responses				*Negative Responses*			
	Degree of Completeness of Data							
	A	*B*	*C*	*X*	*X*	*C*	*B*	*A*
				Men				
Br.	90	83	75	—	81	84	63	100
Dg.	64	49	57	62	79	69	58	60
Ed.	75	53	—	—	71	61	42	75
Hp.	88	63	61	—	92	59	51	12
Kt.	88	70	74	—	83	67	32	61
Lik.	74	83	58	—	91	86	70	25
Ng.	63	55	32	10	68	75	46	24
Pa.	75	03	100	—	91	69	59	24
Sch.	88	72	71	26	77	75	65	73
Sw.	88	67	11	15	100	96	49	51
Sh.	54	88	18	90	84	76	61	68
Slv.	65	43	—	13	82	92	92	77
Tt.	58	41	90	—	86	92	77	95
V. O.	68	44	39	26	77	64	49	75
Vi.	68	68	62	78	69	74	43	54
Wst.	79	59	64	46	84	94	82	100
Wk.	59	50	66	19	91	73	71	—
Wd.	51	58	95	25	70	49	40	33
Ba.	45	33	25	15	72	34	29	37
Eth.	93	61	100	—	100	94	100	91
Gz.	56	67	10	05	68	69	69	52
Hd.	84	92	84	45	95	65	78	10
Hl.	97	85	—	—	92	88	100	72
Hg.	83	89	62	—	100	97	86	93
Hr.	97	32	37	—	94	99	84	79
Hn.	62	63	46	20	74	61	52	72
Klg.	53	56	09	05	71	38	32	38
Kg.	71	82	65	—	77	62	31	57
Lgb.	65	38	38	10	83	75	51	59
Lw.	79	75	67	—	100	100	57	100
Nb.	77	81	25	—	83	80	52	47
Po.	91	81	68	—	84	70	95	54
St.	90	92	100	48	89	94	83	90
Shu.	83	77	57	—	90	83	82	92
Sl.	93	85	58	—	85	88	—	52
Wtn.	84	72	80	23	81	64	60	29
Al.	74	64	56	45	85	70	78	74
Bo.	84	56	94	64	92	81	90	—
Brn.	82	45	56	30	71	55	50	42
Cl.	74	59	46	—	88	82	74	—
Dk.	66	90	16	—	57	29	53	38
Fl.	76	82	78	—	94	83	70	50
Fr.	28	45	39	—	73	63	69	66
Gr.	37	49	69	43	65	33	33	18
Is.	93	92	58	91	78	56	64	61
Jk.	63	37	46	15	79	54	70	34
Lk.	57	40	—	—	93	49	36	19
Mac.	54	11	24	28	72	48	47	32
Ml.	76	73	33	—	60	49	36	30
My.	96	100	—	—	76	74	55	70
Nr.	87	64	48	—	72	58	80	58
Pi.	73	93	78	—	100	94	90	87
Wm.	60	36	40	—	59	28	22	54
Wt.	86	97	88	70	98	39	77	81

	A	B	C	X	X	C	B	A
				Women				
Bl.	60	28	40	—	71	63	45	10
Bd.	99	80	65	58	95	89	87	72
Bu.	70	89	87	08	92	80	51	86
Dt.	54	35	31	—	61	32	10	—
DuB.	86	83	65	37	81	77	31	50
Ec.	63	59	25	10	75	62	44	50
Fb.	85	50	50	—	95	89	74	84
Ga.	89	72	100	55	86	71	07	36
Jo.	71	68	20	—	72	75	30	—
Kc.	79	81	65	—	98	100	64	05
Kt.	96	93	100	—	95	84	75	18
Lg.	96	80	71	—	82	66	63	05
Ra.	86	81	20	—	90	88	81	84
Sd.	72	93	100	—	79	82	86	87
Swz.	85	75	68	18	90	100	74	100
Wat.	84	69	—	—	79	100	64	78
Wil.	72	89	83	—	85	91	77	64
Zt.	67	74	40	—	90	76	63	53
By.	93	81	79	70	81	90	95	100
Ch.	60	60	85	—	87	97	96	67
Cr.	86	88	59	10	85	52	60	40
Dc.	85	73	70	—	87	96	16	73
Frd.	87	83	28	25	90	83	92	80
Grb.	38	29	58	35	61	38	38	45
Ha.	80	76	80	50	59	62	41	79
Hy.	72	65	57	40	88	72	69	61
Jr.	77	66	10	08	98	86	69	03
Kr.	87	90	73	—	90	82	—	57
Mc.	94	41	05	25	98	77	53	38
Mt.	93	92	99	—	99	98	96	99
Rs.	77	64	35	—	80	69	66	60
Rw.	96	51	66	01	90	79	40	49
Stk.	91	78	65	33	67	63	17	80
Sut.	65	83	—	—	80	53	87	43
Wtr.	95	97	76	88	99	88	81	64
Wl.	90	80	44	65	79	30	60	60
As.	87	94	90	90	96	85	93	82
Cp.	35	26	27	—	39	18	12	28
Cs.	66	72	46	15	70	65	50	34
Dv.	36	53	25	—	70	63	55	48
Fra.	63	88	75	58	85	83	76	75
Ggr.	45	42	46	45	50	50	48	45
Grt.	79	61	61	—	85	65	63	39
Gu.	88	99	95	—	98	90	79	95
Hal.	96	68	71	—	93	70	53	37
Hrg.	67	95	39	—	90	85	90	68
Hil.	96	100	83	51	91	96	99	63
Hb.	63	52	29	—	87	79	47	59
Jon.	69	100	29	—	68	48	62	37
Kl.	85	88	87	82	99	99	79	98
Rb.	93	84	86	28	74	61	71	82
Shn.	76	82	43	32	56	50	46	50
Sy.	54	72	84	—	86	73	70	44
Wh.	68	59	85	100	73	77	67	—

APPENDIX II

Average Raw Scores in Recognition Time*

	Positive Responses Degree of Completeness of Data				*Negative Responses*			
	A	*B*	*C*	*X*	*X*	*C*	*B*	*A*
				Men				
Br.	192	291	263	—	287	255	869	330
Dg.	91	85	95	60	103	109	143	97
Ed.	148	155	—	—	122	123	155	125
Hp.	132	152	122	—	114	227	332	373
Ktr.	151	179	177	—	134	167	344	142
Lik.	253	343	369	—	119	140	202	176
Ng.	133	165	245	160	208	173	224	297
Pa.	231	324	144	—	186	243	313	346
Sch.	87	92	76	88	96	87	102	74
Sw.	73	81	79	74	72	83	71	64
Sh.	119	94	140	122	114	129	122	175
Slv.	151	160	—	244	133	115	114	139
Tt.	167	253	304	—	150	119	198	99
V.O.	123	113	321	136	129	118	159	117
Vi.	156	191	254	191	272	163	328	276
Wst.	96	98	100	73	109	125	166	119
Wk.	152	328	179	196	154	155	207	—
Wd.	135	120	71	130	123	146	121	126
Ba.	327	403	652	281	186	337	590	406
Eth.	154	250	193	—	85	144	105	109
Gz.	171	161	175	332	174	156	204	275
Hd.	358	263	379	415	312	419	544	2048
Hl.	160	207	—	—	209	200	186	116
Hg.	479	226	264	—	231	207	268	243
Hr.	425	1173	1213	—	340	278	865	753
Hn.	253	241	507	370	208	422	462	280
Klg.	168	167	295	482	150	318	411	586
Kg.	108	99	198	—	104	124	182	179
Lgb.	166	275	499	244	146	180	368	229
Lw.	304	161	315	—	97	150	235	122
Nb.	166	181	270	—	201	184	267	313
Po.	98	102	129	—	125	117	136	147
St.	186	190	367	261	172	182	220	282
Shu.	135	153	183	—	115	169	155	109
Sl.	278	371	464	—	391	345	—	628
Wtn.	163	231	232	535	255	458	531	434
Al.	125	129	143	135	91	94	85	109
Bo.	91	115	81	110	99	93	104	—
Brn.	104	285	149	307	136	168	129	173
Cl.	115	144	127	—	96	99	118	—
Dk.	372	161	701	—	374	543	455	662
Fl.	484	467	272	—	398	412	481	575
Fr.	591	455	471	—	375	347	407	386
Gr.	102	177	157	104	135	144	285	260
Is.	285	276	861	573	288	1667	772	607
Jk.	128	139	209	107	120	124	123	138
Lk.	146	234	—	—	88	169	197	163
Mac.	303	408	493	144	273	420	405	557
Ml.	211	179	339	—	316	291	452	632
My.	115	155	—	—	106	116	116	113
Nr.	213	510	585	—	324	536	289	411
Pi.	780	274	323	—	185	287	416	270
Wm.	210	173	160	—	148	169	174	197
Wt.	141	127	176	151	133	231	175	225

	A	B	C	X	X	C	B	A
				Women				
Bl.	551	1249	650	—	551	848	1244	713
Bd.	168	248	212	131	153	183	189	270
Bu.	108	102	106	76	95	123	154	106
Dt.	186	253	234	—	201	177	250	—
DuB.	165	192	177	302	200	188	487	222
Ec.	220	260	420	325	181	256	279	187
Fb.	179	305	344	—	113	136	198	161
Ga.	161	214	160	105	180	190	241	169
Jo.	162	221	196	—	280	206	274	—
Kc.	152	236	211	—	122	121	282	516
Kt.	110	162	100	—	154	144	240	359
Lg.	111	151	144	—	111	126	119	167
Ra.	141	167	160	—	123	115	224	128
Sd.	242	151	121	—	170	255	166	95
Swz.	202	189	154	396	128	122	238	111
Wat.	335	292	—	—	228	176	319	203
Wil.	233	164	141	—	184	117	360	565
Zt.	212	194	280	—	171	206	225	247
By.	112	113	133	101	149	160	120	150
Ch.	198	310	230	—	160	131	130	152
Cr.	131	121	161	302	169	186	260	169
Dc.	152	134	147	—	138	137	326	207
Frd.	119	120	173	156	114	111	83	119
Grb.	250	383	389	279	262	266	351	205
Ha.	223	248	249	387	271	291	342	153
Hy.	130	277	155	238	149	259	331	343
Jr.	156	204	416	294	117	154	232	148
Kr.	191	211	157	—	133	200	—	244
Mc.	159	253	127	301	139	324	526	335
Mt.	188	122	210	—	225	197	394	207
Rs.	115	195	195	—	123	213	313	134
Rw.	100	89	58	146	86	106	125	121
Stk.	111	139	177	212	171	130	224	255
Sut.	312	133	—	—	361	427	225	526
Wtr.	191	199	430	283	267	298	712	853
Wl.	117	105	148	88	111	284	138	153
As.	148	133	201	115	135	141	166	176
Cp.	244	269	317	—	218	257	275	354
Cs.	86	98	81	119	107	148	159	171
Dv.	199	363	244	—	197	197	229	345
Fra.	1251	260	947	1592	245	597	475	391
Ggr.	97	116	128	143	121	156	200	179
Grt.	252	489	312	—	180	430	313	408
Gu.	160	185	179	—	113	183	147	255
Hal.	142	325	297	—	138	197	180	222
Hrg.	360	185	405	—	256	277	288	473
Hil.	150	126	159	218	142	137	140	272
Hb.	235	194	318	—	175	184	207	305
Jon.	274	177	314	—	185	242	346	268
Kl.	127	121	279	94	110	128	255	215
Rb.	134	169	230	138	128	130	187	129
Shn.	139	147	188	123	241	149	348	325
Sy.	252	322	186	—	141	283	233	350
Wh.	186	211	239	252	225	248	367	—

* Measured in hundredths of a second.

VITA

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